The Gross National Health Product: A Proposed Population Health Index

MARTIN K. CHEN, EdD

IN AN ARTICLE entitled, "The Health of the American People," published in the June 1966 issue of Scientific American (*1*), Forrest E. Linder, a former director of the National Center for Health Statistics, said that someday it might be possible to develop a GNP-like health index to be called the gross national health deficit (GNHD) that "could blend together in one number the days of healthful living lost each year by the chronically and acutely ill, the days of life lost through death that comes too soon and all the impairment suffered for lack of medical treatment and advice." Linder saw as a major problem in designing such an index the lack of commensurability in the units of measurement for combining mortality and morbidity data into a single number, "such as the economists' dollar."

In view of the current emphasis on small-area statistics for health planning purposes, one may wonder why a global measure of population health status is necessary. Although Linder did not discuss the utility of a global measure in his paper, his likening of the measure to the GNP suggests that he probably envisioned a population health index that could serve the same purpose in health as the GNP serves in economics: an overall, albeit it gross, index of the state of health in any given year. Conceivably, in his annual State of the Union message the President could include a brief statement on the health status of the nation once a valid population index is developed and accepted. For such a purpose, life expectancy would be unsatisfactory because it reflects only the mortality experience of the population.

In this paper, I propose a methodology to overcome the problem of incommensurability of measurement units in the design of a gross national health product (GNHP). As the term indicates, the proposed index of health is not intended to be a refined measure of the nation's health, just as the GNP is not a precise index of the nation's economic health. It is well known among economists that the GNP has serious deficiencies; the most serious is that it can be misleading as an index of economic health because it does not take into consideration the economic consequences of production. For instance, if a chemical plant produced $2 million worth of chemicals in a given year but in the process did $3 million worth of damage to the ecology, the GNP would reflect only the fair market value of the chemicals, not the damage to the ecology. Thus, the GNP could present a false picture of the nation's economic health. The proposed GNHP does consider the negative side of health status to the extent that it is reflected in a population's disability experience.

Just as the GNP ignores the negative side of eco-

Tearsheet requests to Dr. Martin K. Chen, Senior Researcher, Division of Intramural Research, National Center for Health Services Research, Room 8–30, Center Bldg., 3700 East–West Highway, Hyattsville, Md. 20782. *An abstract of this paper was presented at the Public Health Conference on Records and Statistics, June 5–7, 1978, Washington, D.C.*

nomic growth, so the proposed GNHP, by virtue of its nature, sidesteps the issue of what is known as "positive health" because a scientifically satisfactory definition of "positive health" does not yet exist—despite a plethora of such definitions in the literature. A review of a sample of the definitions that I presented in 1975 (*2*) reveals that either the definitions are mere tautologies or they incorporate undefined terms. Thus, designers of population health status indices must by necessity focus on the negative aspects of health—mortality and morbidity or disability.

The proposed GNHP blends a nation's mortality and disability statistics into a single number in units of disability-free life years lived per 100,000 population. The index is a quantitative measure that only tangentially touches on quality in the sense that, in general, a higher rate of disability among the surviving population may indeed reflect a poorer quality of life. However, the index is incapable of indicating the quality of life of the "healthy" segment of the surviving population that does not become mortality or disability statistics. Furthermore, insofar as mortality and disability do not reflect the extent of physical and emotional suffering, the GNP does not take into account such suffering. As the title implies, the GNHP is only a gross index of population health status.

Other Population Health Indices

The proposed GNHP does not constitute the first attempt at combining mortality and disability or morbidity data into a single index of health. In his pioneering work, Chiang (*3*) outlines a sophisticated statistical procedure for transforming mortality and morbidity statistics into fractions of the year lost and deriving an index that is simply the remaining fraction of the year after subtraction of the combined fraction of the year lost due to mortality and morbidity. One problem with Chiang's index is that data are required for estimating the duration of illness, and such data are not currently available. Even if these data could be obtained, it is unlikely that the index would be used because the mathematics used in its derivation would be too complicated for most health administrators.

An index by Sullivan (*4*) is conceptually straightforward and easily computable. Sullivan reasons that average life expectancy at birth does not reflect the quality of life because it is conceivable that a person can live a long time as an invalid or semi-invalid. To correct this deficiency, he adjusts the number of years lived by an age group by weighting it with a factor that is a function of the disability experience of that age cohort, resulting in what might be called a "disability-adjusted life expectancy."

Although Sullivan's formulation is an improvement over the traditional current life table based solely on mortality data, his adjusted life expectancies are not a single global measure of population health status. Life expectancy at birth, whether adjusted for disability or not, is, of course, indicative of the health status of a population; nonetheless, it is not a comprehensive measure of the health status of all age groups, whose life expectancies must still be examined individually to obtain a complete picture of the population's health status. Thus, Sullivan's index of mortality and morbidity differs from the proposed GNHP, which is a unitary measure of the health status of the entire population adjusted for differences in size of age groups.

My population index (*5*) is a ratio of two averages—the average of the mortality rates of five population groups to the average of the proportions of the survivors of the same five groups that are free from disability in a given year of interest. The rationale of the index is simple. If the average mortality rate of a population is high, but somehow a large proportion of the surviving population is free from disability, then the higher mortality rate should be balanced out with the lower disability rate and vice versa. A special feature of the index is that the index values are only slightly sensitive to the disability rates until the rates reach the 30 percent level, when the index values become increasingly sensitive to disability. The effect of this feature is the differential weighting of disability before and after the 30 percent level. Disability after the 30 percent level is given heavier weights as the rates increase. The implication is that disability is not as serious as mortality unless the disability rates become excessive. Whether this feature is desirable is a philosophical question that cannot be readily answered.

Another index that I have proposed (*6*) combines deaths and disability days in a probabilistic way that takes into account discrepancy in health status between a set of normative populations that are known to be "healthy" and a sample of populations under study. Although the intent of the index is to be a tool for monitoring the quality of health services, it can serve as an index of negative health for ranking several populations. However, the value of the index is lessened considerably because of the quite difficult statistical procedures required for its derivation and the complex computations in actual application.

The GNHP

The proposed index uses four kinds of data, all of which are available from the National Center for Health Statistics (NCHS). The data are (*a*) total number of disability days from both acute and chronic conditions by age, (*b*) total number of deaths from all causes by age, (*c*) size of population by age, and (*d*) life expectancies by age. The computations are simple and can be done with a simple hand-carried calculator with the four arithmetic functions—adding, subtracting, multiplying, and dividing. In the computational example, the data are obtained from two NCHS publications that provide life-table and disability data for 1971 (*7, 8*). Population size by age is available in NCHS computer printouts used in computing mortality rates by age. The data are presented in table 1.

The age group intervals in table 1 are not equal, as a result of my having to collapse age groups to achieve comparability because the two NCHS publications, dictated by the necessity of adjusting population sizes to Bureau of Census figures, displayed mortality and disability data by different age groups.

The computational procedures based on data from table 1 are shown in table 2. The computed parameters are as follows: $S = 100{,}000\,[(n - M)/n]$ is the survival rate per 100,000 population. $E = S \times \hat{e}$ is the number of life years per 100,000 of the surviving population are expected to live, $\hat{e}$ being the life expectancy of people in the median age of the group interval. $Y = 100{,}000\,(D/365n)$ is the number of life years lost per 100,000 of the population due to disability. $F = E - Y$ is the number of disability-free life years per 100,000 of the population are expected to live. And GNHP $(A_w = (n_1F_1 + n_2F_2 + n_3F_3) + n_4F_4)/(n_1 + n_2 + n_3 + n_4)$ is the average number of disability-free life years per 100,000 of the entire population of a geographic region are expected to live, taking into consideration varying population sizes in the different age groups.

Interpretation and Discussion

The results for all age groups (that is, the entire population of a geographic region) show that in 1971 people in the West were expected to live, on the average, 4,313,660 disability-free life years per 100,000 population, as compared with 4,288,002 in the South, 4,262,-456 in the North Central States, and 4,166,550 in the Northeast (table 2). The differences do not appear substantial, particularly when it is noted that the disability component or *D* of the index is subject to sampling error, even though population sizes are not, because the population sizes have been adjusted to Bureau of Census figures (*9*). It is therefore necessary to consider the standard error of estimate of this component for greater insight into the differences found.

It is well known that, other things being constant, as the size of the estimate increases the relative standard error decreases. To be conservative, I use the smallest estimated *D* value in table 1, which is 20,436,000 for the under-5 group in the North Central States, and find its standard error, which is roughly 1.8 percent $\times$ 20,436,000 days = 367,848 days or 1,008 years (*9a*). This finding means that the chances are 95 out of 100 that the estimate from the sample would differ from a complete census by less than $2 \times 1{,}008 = 2{,}016$ years. Table 2 shows that *Y* or disability made a real contribution (although negative) to the *F* values only by the 65 and over age groups for all regions and the 44-65 age group in the South. The other *Y* values could be accounted for by sampling error.

The GNHP (A_w) values also reveal that the values are affected by one or all of three factors—the survival rate, life expectancy, and the disability rate. If life expectancy is held constant, a higher survival rate, which should increase the value of GNHP, could be offset by a higher disability rate, which should decrease the value of GNHP. Thus, the values of GNHP in themselves do not differentiate the influence of survival rate or disability rate. If such information is desired, it is easy to refer to the parameters in table 2, particularly *S* and *Y*.

Taking the difference between *E* and *Y* to derive *F* implicitly assumes that a life year lost due to death is exactly the same as a life year lost due to disability; that is, mortality, which affects the survival rate and life expectancy, is given the same weight as disability. My justification for so doing is that the life year is a convenient unit of measurement for the GNHP, just as the dollar is a convenient unit of measurement for the GNP. And just as the GNP does not differentiate a dollar earned by a janitor from a dollar earned by a chemical plant, so my GNHP does not differentiate life years lost due to mortality and disability.

It may be argued that this analogy is inappropriate because the purchasing power of the dollar is the same regardless of its source, but not the emotional impact of death and disability. This argument is, of course, valid. However, the GNHP is intended to be a gross quantitative measure of health that is not concerned with the affective or even economic aspects of life. To incorporate such aspects into the index, the index must go into the ramifications of familial and social relationships and the differential earning powers of the deceased and survivors—a task that is difficult but certainly not impossible, provided the requisite data are available. Such an index would still be a gross index of health, but it would be much more comprehensive and refined than the proposed GNHP.

The proposed GNHP can be used to monitor the gross health status of regions or nations over time or compare different nations or regions, as is done in table

Table 1. Raw data matrix for computing gross national health product (GNHP) by age group and region

Age group and data	*North East (New England and mid-Atlantic)*	*North Central (East North Central and West North Central)*	*South (South Atlantic, East South Central, and West South Central)*	*West (Mountain and Pacific)*
Under 5 years				
Days of disability (D_1)	25,260,000	20,436,000	25,367,000	22,488,000
Number of deaths (M_1)	16,038	21,573	28,986	12,615
Subpopulation size (n_1)	3,462,000	4,445,000	5,490,000	2,904,000
Life expectancy of median age of group interval ($\hat{e}_1$)	71	71	71	71
5–44 years				
Days of disability (D_2)	140,266,000	145,063,000	182,999,000	127,709,000
Number of deaths (M_2)	37,895	43,996	62,190	30,152
Subpopulation size (n_2)	29,522,000	35,487,000	41,497,000	23,446,000
Life expectancy of median age of group interval ($\hat{e}_2$)	51	51	51	51
44–65 years				
Days of disability (D_3)	75,742,000	68,245,000	113,569,000	53,197,000
Number of deaths (M_3)	122,421	124,179	154,335	72,613
Subpopulation size (n_3)	11,001,000	11,591,000	13,299,000	7,431,000
Life expectancy of median age of group interval ($\hat{e}_3$)	24	24	24	24
65 years and over				
Days of disability (D_4)	57,145,000	62,051,000	107,684,000	29,492,000
Number of deaths (M_4)	320,991	350,611	349,547	178,624
Subpopulation size (n_4)	5,440,000	6,020,000	6,893,000	3,463,000
Life expectancy of median age of group interval ($\hat{e}_4$)	10	10	10	10

Table 2. Computational procedures of gross national health product (GNHP)[1] by age group and region

Age group and parameter	*North East (New England and mid-Atlantic)*	*North Central (East North Central and West North Central)*	*South (South Atlantic, East South Central, and West South Central)*	*West (Mountain and Pacific)*
Under 5 years				
Survival rate (S_1)	99,536.7	99,514.7	99,472.0	99,565.6
Number of years surviving population expected to live (E_1)	7,067,109	7,065,541	7,062,514	7,069,152
Years lost due to disability (Y_1)	16,244	1,260	1,266	2,122
Difference between E and Y (F_1)	7,050,865	7,064,281	7,061,248	7,067,030
5–44 years				
Survival rate (S_2)	99,781.6	99,876.1	99,850.1	99,871.5
Number of years surviving population expected to live (E_2)	5,093,452	5,093,681	5,092,357	5,093,447
Years lost due to disability (Y_2)	1,302	1,120	1,208	1,492
Difference between E and Y (F_2)	5,092,150	5,092,561	5,091,149	5,091,955
44–65 years				
Survival rate (S_3)	98,887.2	98,928.7	98,839.5	88,022.8
Number of years surviving population expected to live (E_3)	2,373,293	2,374,288	2,372,148	2,376,548
Years lost due to disability (Y_3)	1,886	1,613	2,340	1,961
Difference between E and Y (F_3)	2,371,407	2,372,675	2,369,808	2,374,587
65 years and over				
Survival rate (S_4)	94,099.4	94,175.9	94,929.0	94,841.9
Number of years surviving population expected to live (E_4)	940,994	941,759	949,290	948,419
Years lost due to disability (Y_4)	2,878	2,824	4,280	2,333
Difference between E and Y (F_4)	938,116	938,935	945,010	946,086
All groups, GNHP (A_W)	4,166,550	4,262,456	4,288,002	4,313,660
Rank	4	3	2	1

[1] All numbers, averages, rates, and differences are per 100,000 population.

[2] Number 1 is the highest rank in terms of overall health status in disability-free life years.

2. Regardless of the purpose for which it is used, it is always desirable to refer to the data in table 1 and the computed parameters in table 2 to derive insights into the nature of any difference that may be found. For instance, the GNHP values for the West, which ranks first, and for the Northeast, which ranks last, are appreciably different. What is the reason for this difference? Table 2 shows that in all age groups, except the 5-44 group, the survival rates in the West are higher than in the Northeast; in the 5-44 year age group, there is no practical difference. Again excluding the 5-44 age group, the disability rates are also higher in the Northeast than in the West. Thus both sources—survival rate and disability rate—contribute to the difference in GNHP values in this particular case.

In the computational example, the life expectancies are held constant across all geographic regions by use of national life table data. If regional life tables were available, it would be more accurate to use regional life expectancies. In making comparisons among nations, it is crucial to use accurate national life expectancies since they affect the GNHP values substantially.

Needless to say, the definition of disability must be standardized in cross-national or cross-regional comparisons. Unless this is done, the disability rate is meaningless in that a disability day in one nation may not be counted as such in another. Furthermore, the criteria for disability should be uniformly adopted. For instance, in one region or country it may be customary for a person to stay home from work if he has a slight fever, but a person in another region or country with a similar condition may report to work as usual. I do not discuss the problems of data quality in general because they have been adequately dealt with elsewhere (*10*). Suffice it to say here that disability data based on varying individual or regional tolerances of ill-defined sick role behavior would seriously bias international or inter-regional comparisons of health status

Conclusion

Despite its limitations, the GNHP can be a useful measure of the general population's health status in cross-regional comparative studies, provided that data on disability are standardized. For instance, the GNHP can be used to monitor the performance of health systems agencies (HSAs) over time or to compare several HSAs cross-sectionally at a given time. Because the GNHP can be easily computed and interpreted—with few sophisticated health measurements—health planners should find it a useful tool.

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SYNOPSIS

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A population health status index designated as the gross national health product (GNHP) is proposed as a general measure of the health of nations or population groups. The GNHP integrates mortality and disability data into a single number in units of disability-free life years lived per 100,000 population. It is based primarily on mortality ratios and life expectancies of component age groups of the population, modified by their respective disability experiences.

A computational example with data currently available on U.S. geographic regions from publications of the National Center for Health Statistics shows that the GNHP was highest in the West, indicating the highest number of disability-free years lived. Because of simplicity in its computation and interpretation, the GNHP can be used by health systems agencies (HSAs) in monitoring their performance or in conducting comparative studies.